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13. ABSTRACT (Maximum 200 words)

Field and modeling studies of nearshore morphology aims to understand and predict sediment-transport mechanisms and their morphologic expression in the coastal marine environment, with particular emphasis on surf zone evolution. Principal goals are to effectively and economically predict bathymetric and sedimentologic evolution over a variety of time and length scales, to understand the degree of coupling between the scales, and to determine the level of uncertainty in predicting bathymetric evolution. Primary field focus was to study effects of insufficient sediment supply on nearshore morphology, such as that common to coastal North Carolina.

ARO and CHL supported development of a LARC-mounted interferometric sidescan bathymetry system. The system simultaneously provides high-resolution, swath bathymetry and sidescan sonar images of the seafloor. Repeated surveys at the Field Research Facility at Duck, NC reveal outcropping muddy substrates associated with anomalous nearshore bar behavior in an otherwise sandy beach setting. Aerial photographs spanning a twenty-year period show persistent, recurring differences in bar morphology between the study site and adjacent areas. Video imagery also shows that the nearby shoreline has a much higher variance in erosion and accretion than the surrounding shoreline.

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for

Field and Modeling Studies of Nearshore Morphology

Grant # DAAG55-97-1-0358

by

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Statement of the problem

Bathymetric patterns formed in response to waves and currents in the nearshore reflect characteristics of suspended and bedload sediment transport processes. Predicting such processes and the resulting bathymetry is an elusive goal of considerable value for Army and other DoD operations in the nearshore environment, and to Army and civilian coastal engineering efforts. The usual approach to prediction of bathymetric evolution requires knowledge of a host of fluid, sedimentologic and bathymetric parameters — exceedingly difficult and time-consuming to measure under excellent conditions— which then drive models of significant uncertainty. In particular, sediment transport processes in areas with insufficient sediment supply are poorly known; such conditions are common on much of the Atlantic coast of the United States and in fact dominate on portions of the Outer Banks of North Carolina. Observations of surf zone bathymetry and bedform patterns are difficult to obtain, which has hindered efforts to develop predictive models for nearshore morphologic evolution. Such observations form the basis for the work described below.

Summary of results

The Army Research Office and Coastal Hydraulics Laboratory supported development of a LARC-mounted interferometric sidescan bathymetry system, purchased in 1998 with ARO-DURIP funding. The system simultaneously provides high-resolution swath bathymetry and sidescan sonar images of the seafloor in the surf zone, and is, to the best of our knowledge, the only existing amphibious swath bathymetry system in operation. Repeated surveys over the last two years at the U.S. Army Engineer Waterways Experiment Station, Field Research Facility (FRF) at Duck, North Carolina reveal outcropping muddy substrates associated with anomalous nearshore bar behavior along a nominally sandy, highly two-dimensional beach. Much of the survey work and analysis was undertaken by Dr. Jesse E. McNinch, National Research Council postdoctoral fellow at the FRF. The beach immediately south of the present study area served as

the field site for numerous intensive field studies of nearshore processes, most recently, the Duck94 and SandyDuck97 nearshore field experiments. The focus of those experiments was prediction of morphologic evolution; and a common assumption of workers at the site is the availability of sufficient sediment supply to ensure so-called "transport-limited" conditions. Transport-limited refers to conditions where the actual sediment transport rates are not constrained by availability of material to transport. When an insufficient supply of sediment exists, then the actual transport will be less than the potential transport. Such conditions are difficult to address analytically and require difficult-to-obtain information for implementation in numerical models. Thus the importance of ascertaining whether insufficient supply conditions may exist at Duck, where extensive datasets are used for development and testing of models for nearshore bathymetric evolution.

A series of aerial photographs of the beach at Duck spanning a twenty-year period starting in 1977 show persistent, recurring differences in bar morphology between the present study site and adjacent areas, in particular those areas intensively studied during Duck94 and SandyDuck97. ARGUS video imagery also shows that the shoreline bordering the stretch of beach closest to the outcrops and irregular bars has a much higher variance in erosion and accretion than the surrounding shoreline. Such anomalous areas are called hot-spots and the mechanism(s) for their formation and maintenance are of much interest in the nearshore community. Irregularities in the bars and beach probably result from differences in both the underlying geology and the thickness of the overlying sand compared to adjacent non-hotspot areas. A reconnaissance chirp seismic survey conducted in September 2000 shows a surface sand layer having a highly variable thickness. The sand layer rests on an older non-sandy substrate that lies less than 50 cm below the seafloor surface in several locations within the study area. Moreover, surface sediment samples and vibracores collected in conjunction with the geophysical surveys confirm the presence of isolated and ephemeral spots of non-sandy sediment, both mud and gravel, exposed in the surf zone. Our findings provide strong circumstantial evidence that a non-sandy underlying substrate, when present near the seafloor surface, influences bar behavior and ultimately beach erosion and

accretion. The physical mechanisms responsible for this relationship, however, remain unclear. We have generated cellular-automata models for transport of sand over so-called "hard-bottoms," but presently such models lack necessary observational or theoretical underpinnings. Such phenomena are quite general; for example, we have observed eolian sand transport on roads and over wet sand substrates that is roughly analogous to the nearshore case and has, in fact, formed the basis for phenomenological transport models.

Publications

a) Papers in peer-reviewed journals: None to date.

b) Papers in non-peer-reviewed journals or conference proceedings:

Ed Thornton, Tony Dalrymple, Tom Drake, Edie Gallagher, Bob Guza, Alex Hay, Rob Holman, Jim Kaihatu, Tom Lippmann, Tuba Ozkan-Haller, 1999, State of Nearshore Processes Research: II, Report Based on the Nearshore Research Workshop, St. Petersburg, Florida,September 14-16, 1998, Technical Report NPS-OC-00-001, Naval Postgraduate School, Monterey, California

c) Papers presented at meetings:

Drake, T.G., 2000, Bridging fluid-dynamic and geologic perspectives of the shoreline: Geological Society of America, GSA Abstracts with Programs, 32 (2), p. A16.

McNinch, J. E., and Drake, T.G., 1999, Influence of underlying geology on shoreface bathymetry and sediment distribution at Duck NC: EOS Trans. AGU, 80(46), Fall Meeting Suppl., F548.

Dickson, P.J., Gallagher, E. L., and Drake, T.G., 1999, Bathymetry and bottom characteristics in the surf zone during SandyDuck: EOS Trans. AGU, 80 (17), Spring Meeting Suppl., S194.

d) Manuscripts submitted but not published:

McNinch, J.E. and Drake, T.G., in preparation, Influence of underlying geology on nearshore processes at Duck, North Carolina, to be submitted to Journal of Geophysical Research

Drake, T.G. and McNinch, J.E., in preparation, Modeling anomalous nearshore bar behavior on two-dimensional beaches with insufficient sediment supply, to be submitted to Journal of Geophysical Research

McNinch, J. E., Wells, J.T. and Drake, T.G., Scour and sediment transport: exhumation of the Queen Anne's Revenge: submitted to Southeastern Geology

e) Technical reports: none

Scientific Personnel:

Scientific personnel supported by this grant include: principal investigator Drake and graduate students Peter Dickson, Ansley Wren and David Bernstein. Mr. Dickson is expected to complete a Masters of Science degree in Geophysics in the very near future. Ms.Wren has entered the PhD Program in Marine Sciences and will pursue studies of sediment transport under separate funding. Mr. Bernstein is expected to complete a Masters of Science degree in Geology in Spring 2001. An important addition to the scientific personnel is ARO-National Research Council Post-Doctoral Fellow Dr. Jesse McNinch, presently in residence at the Army Field Research Facility (FRF) at Duck, North Carolina. Though this project does not support Dr. McNinch financially, much of the work described above was performed in close collaboration with him. Dr. McNinch has accepted a tenure-track faculty position at the Virginia Institute of Marine Sciences (VIMS) of The College of William and Mary and will begin in that capacity in 2001.

Inventions:

No inventions were produced.

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